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Conservation of Mangroves: Challenges and Prospects in the Scarcies River Estuary, Sierra Leone

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Abstract *—The study aimed at investigating the challenges and prospects of mangrove restoration and conservation in the Scarcies River Estuary, a prerequisite for effective management planning. A total of 200 participants were interviewed in five coastal communities through Focused Group Discussion and Key Informant Interviews using structured questionnaires. Generally, 60.5% of participants cleared mangroves for commercial rice farming, of which Rokupr (16.5%) and Mambolo (15%) recorded the highest. 22.5% converted mangroves for commercial salt production, and dominantly practiced in kasseri (6.5%) and Kychom (7.5%). 17.5% had cleared mangrove for infrastructural development of which Yeliboya recorded the highest (11.5%). There was an overly weak correlation (r = -0.014) between conversions to 'rice field' and 'salt production' as the dominant aspects of conversions of mangroves, and the difference between them was significant (p < 0.05). Moreover, rice farming (38.5%) and fishing (27.5%) were key economic activities in the study areas. In conclusion, the low financial capacity to explore other income options could be compelling incentives for the conversion of mangroves, a disincentive for resource conservation in the study areas. Training in livelihood diversification and support through loans should be considered in planning for mangrove restoration and conservation in this region.*

Keywords — *Ecosystem, governance, incentive, open access, sustainability*

I. INTRODUCTION

Estuaries are marine water bodies close to land and the most characteristic vegetation present in the estuarine region is mangrove [19]. The mangroves are woody plant communities situated in the intertidal zone of tropical and subtropical latitudes [18], [26]. The African and Asian continents have been shown to comprise the bulk of global mangrove coverage [55].

Several studies have shown that the mangrove ecosystem is a sanctuary to enormous abiotic and biological resources and offers an array of ecosystem goods and services from which humanity benefits [7], [8], [12], [21], [14], [44], [47], [35], [49]. However, owing to flaws in sustainable management efforts, this uniquely acclaimed ecosystem is constantly under the influence of anthropogenic pressures [54], [56], [67]. The main threats are: Conversion to agriculture or aquaculture [54], [59], [69]; Pollution, hydrological changes and indirect disturbances [36], [53]; overexploitation [24], [48]; Climate change and extreme weather events [25], [16]. It has been postulated that the quest for socio-economic sustainability favored by mangroves is the fundamental driver of mangrove loss and degradation globally [561]. Moreover, Climate Change threatens biodiversity and ecosystem integrity all over the globe [31] and is already triggering pronounced shifts of species and ecosystems [9], [10], [31], [44], [56].

Intact mangrove ecosystem can provide an array of services to humans, which include provisioning services, such as supply of natural resources and food [8], [7], [9], [35]; regulating services, that modify climate and hydrology [3], [7], [43]; mitigates atmospheric carbon levels at global scale[5], [10], [12], [18], [21], [42], [46], [50], [65]; education, cultural and recreation services [14], [47], [68]. It can provide natural protection against extreme weather events and rising sea levels [47]. Also, the ecosystem houses important carbon stocks of key importance to the "blue carbon" trade and can store organic carbon 3-5 times higher than terrestrial forests with greater longevity [71]. Besides, the mangrove ecosystem is among the most economically important and biologically diverse ecosystems on the planet [28], [70]. The economic returns from well-conserved mangrove resources can amount to billions of United States Dollars per-year [13], $751, 368 per-hectare-year [40], and $35,000 per-hectare per-year [29].

In Sierra Leone, the earliest study by [11] had estimated that 47% of the coastline of Sierra Leone was covered with mangroves with a total area of 171,600 hectares. A more recent data from the Landsat image gave an estimate of 152, 575 hectares [59]. Reference [59] had estimated a decrease in total mangrove cover in Sierra Leone by approximately 25% since 1990, with 46% of such decrease in the Scarcies River Estuary, due to widespread conversion of the land to rice farms. Other authors have noted unimaginable degradation of the mangrove forest in Sierra Leone with the highest depletion in the Scarcies Estuary regardless of its potential to sustain local livelihood in the area [37], [38], [59], [60]. According to [52], the mangroves of Sierra Leone decreased by 1% annually. Report by [66] has revealed a decline of 8% at the rate of 0.2% per year in the more pristine and

conserved mangrove areas, the Sherbro River Estuary, South of Sierra Leone.

This study makes the first attempt beyond just regional comparison by singling out potential settlements with plausible challenges to mangrove restoration and conversion efforts in the Scarcies River Estuaries in Sierra Leone. The study also identified prospects for future restoration and conservation endeavors in the region. This provides a platform in the understanding of variation in alternative livelihood interventions at the community level for successful mangrove restoration and conservation efforts in the Scarcies River Estuary.

II. MATERIALS AND METHODS

Study Area

Five coastal communities were selected for the study in the Great Scarcies Estuary, North-Western Sierra Leone coast, Kambia District, situated on 9°10′N, 12°45′W. These are Rokupr, Mambolo, Kychom, Kassiri, and Yeliboya Island (Figure 1).

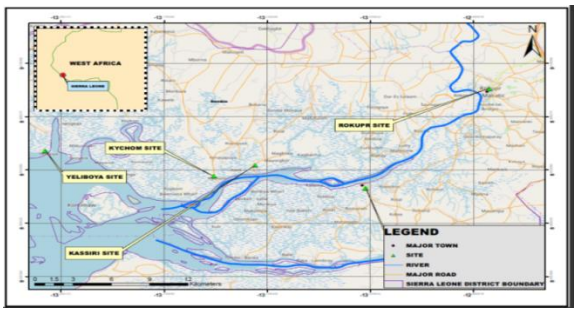

Figure 1. Map showing study locations in the Great Scarcies Estaury

The district is the rice bowl of the country with dominant farming populations compared to fishing [1], [37], [38], [59]. Existing records have revealed that the hydrology of the district mainly constitutes the Scarcies River Estuaries formed by the Great and Little Scarcies, which merge towards their mouth before emptying into the Atlantic Ocean [15], [41]. The Great Scarcies Estuary is tidal and during the rainy season rises to about 2.7 m, and is subject to significant seasonal changes caused by changes in atmospheric conditions [57]. The trade and monsoon winds are the main factors responsible for hydrological changes [41]. However, the Great Scarcies Estuary contains most of the mangrove vegetation in this area [57] and all species of mangrove reported for Sierra Leone have also been noted for the Great Scarcies Estuary River [230], [59], [60]. This area hosts 7.6% of Sierra Leone mangroves which extend inland (8-10 km) and up to 15 km along the river estuary [59].

The climate in this region is consistent with the climatic conditions of the country, a tropical climate with a distinct dry season (November to April) and the monsoonal rainy season which lasts from May- October [15].

The nature of sediment in the study areas was mainly sand/mud and supported both sandy and muddy substrate littoral organisms [2], [36].

Sampling Technique

Respondents were selected through a stratification method where each community was imaginarily divided into 5 strata from a reference point (popular point such as mosque). This technique ensured a fair representation of the population in each settlement [36].

Research Design and Data Collection

Owing to grave constraints involved in accessing the study areas, **s**ampling was conducted intermittently and bi-monthly in 2017 in five major coastal settlements along the Great Scarcies Estuary fringed with mangroves, and 40 respondents were randomly selected from each settlement (N= 200). As a strategy, five focused group discussions were held using structured questionnaires, and participants in each group were numerically limited to eight, while individuals that attracted peculiar topical interest were singly approached as Key Informant Interview. This ensured efficiency in deliberations of issues relating to dependence on the mangrove ecosystem.

Moreover, the applied qualitative approach in data collection using structured questionnaires in participatory methods such as Focus Group Discussions (FGD) and Key informant interviews (KII) were overly essential in enhancing conciseness in the data collection process. These methods made certain of the brevity of information sought from participants, especially when the study couldn't sample every individual in each settlement. Several authors have applied similar data collection approaches [22], [23], [26], [31], [35], [36], [57].

Statistical Treatment

The student's *t*-test of significance was completed using the Microsoft (MS) Excel (ver. 2016) computer analysis tool for PCs. Similarly, percentage means± SE) were computed using descriptive statistics inscribed for PCs. A graphical approach was used to illustrate recorded data

III. RESULTS AND DISCUSSIONS

Challenges

Holistically, commercial rice farming (38.5%), fishing (27.5%), 'sale of mangrove tree products' (12%), 'other mangrove trades' (7.5%), and 'non-mangrove related commerce' (12.5%) constituted the main economic activities in the study areas (Figure 2). 'Oyster and wood' were comprised of the mangrove tree products; while 'other mangrove trades' referred to economic activities such as handicrafts made from mangrove stems as well as trade-in littoral fauna including cockle.

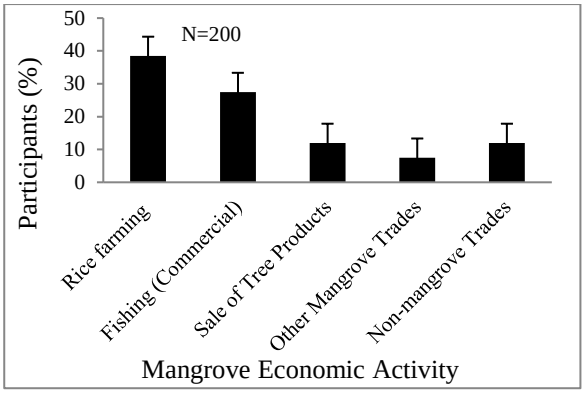

Figure 2. Economic Activities (Source: [38])

The main aspects of the conversion of mangroves in the Scarcies Estuary were for commercial rice field, commercial salt production, and infrastructural development. Figure 3 illustrates variations in the intensities of aspects of conversion of mangrove per community. Generally, 60.5% of participants cleared mangroves for rice farming, of which Rokupr (16.5%) and Mambolo (15%) recorded the highest. 22.5% and 17% of participants were engaged in clearing mangroves for commercial salt productions and infrastructural development respectively. However, commercial salt production was dominantly practiced in Kassiri (6.5%) and Kychom (7.5%) both in the Samu Chiefdom, Kambia District, and the salt produce "Samu Salt" was named after the name of the chiefdom. The salt production process, according to participants, involved desalinating mangrove soil using mangrove firewood in the boiling and evaporation process. Interestingly, clearing of mangroves for infrastructural development emerged as most significant in Yeliboya (11.5%) as shown in Figure 3.

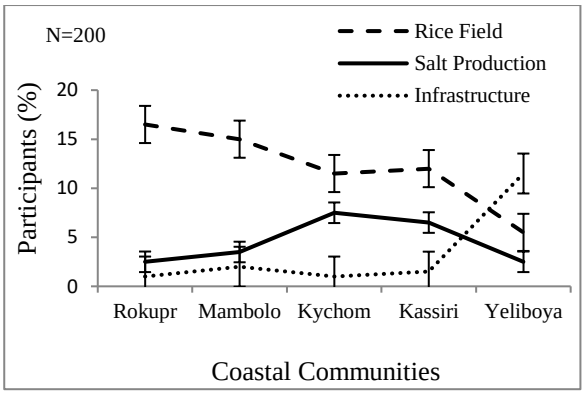

Figure 3. Aspects of conversion of mangroves in the Scarcies Estuary

Mean percentage frequencies of respondents for the aspects of conversions of mangrove to rice fields, salt production, and infrastructural development were, 11±1.9, 5±1.2, and 4±2.5 respectively. There was an overly weak correlation (r = -0.014) between conversions to 'rice field' and 'salt production' as the dominant aspects of conversions of mangroves, and the difference between them was significant ($p < 0.05$; p-value = 0.04; t_{stat} = 2.588; α =0.05; df. 6). This implied that both activities occurred disproportionately and the gravity of their impacts on mangrove resource sustainability was different. The aspects of conversion of mangroves for economic gains, with majorant conversion to the rice field, were coherent with existing records in Sierra Leone by other authors [20], [39], [38], [52], [60]. According to [59], a decrease in mangrove cover in Sierra Leone is due to widespread conversion for rice productions. Other researchers have confirmed unscrupulous conversions of mangroves for coastal agriculture, and are fast becoming a dominant threat to the sustainability of mangroves worldwide [24], [69]. Similarly, salt extraction from mangrove soil has been noted to be driving mangrove forest change in Sierra Leone [33], [38], [60], and the extracted salt from seawater is dried using mangrove wood [48]. Moreover, the conversion of mangroves largely for infrastructure (11.5%) in Yeliboya was indicative of shrinkage of the island probably owing to the land recession by coastal erosion and sea-level rise over time, thereby increasing the dire need by inhabitants to construct new shelter, mainly wattle houses using mangrove trees upon retreating. Reference [59] concur that the coastline of Yeliboya sinks further into the ocean annually as a direct result of the high proportion of the diminishing mangroves that buoy the settlement. This could be an added reason why intact mangrove could be important to Yeliboya.

Further, [37] have noted key drivers of mangrove conversions by coastal communities in the Great Scarcies Estuary, and included "low western educational attainments, inadequate healthcare facilities, the low financial capacity to own basic assets by individuals and generally poor living conditions". Reference [59] has also recorded very high poverty levels, low education levels, very limited access to health centers, and very low access by inhabitants in the Scarcies Estuary to savings and credit facilities. The nationwide scaling cost of living to golf current social and economic needs (e.g., Food, health, education, and income) and the lack of capital by the farming population to engage in other productive economic activities such as fishing, could heighten incentives for the readily accomplishable economic activities such as conversions for rice and salt productions in the Scarcies Estuaries, a disincentive for resource conservation. Reference [63] concur that reduction in household income, lack of basic educational facilities as well as other material needs might result in communities forced into unsustainable forms of income generation where the mangroves provide readily available options, and may tremendously affect the ability and willingness of these communities to conserve their local mangrove forests. According to [53], fishing may be feasible only for those who can afford boats and fuel to travel further afield. Reference [4] had emphasized the need for alternative livelihood to foster positive attitudes towards mangrove conservation among local communities. The lack of education to attract skilled jobs in these areas [37], [59] could heighten the incentives for conversions of mangroves for revenue.

Moreover, mangrove in Sierra Leone is considered a 'common pool resource', implying that the 'use rights' of

the natural capital are 'open access', and jurisprudents in the local government Act (2004) according to participants. Studies concur that indigenous coastal communities have traditional rights to mangroves and depend on them for subsistence [7], [8], [35], [58], [62], [63]. Such use-rights coupled with the inefficient policies governing coastal forests could heighten the overly destructive economic practices, with the potential to undermine resource conservation efforts in the area. Reference [59] concur that most natural resources in Sierra Leone (farmland, fishing grounds, mangroves, and other forests, sand) are open access, and asserted that such use-rights may influence behaviors around resource capture, thereby enabling little incentive for conservation and sustainable management.

Not only, but major policies in Sierra Leone are also either part of a broader legislative framework or are incorporated into various types of machinery in line with ministries or agencies that appear to be conflicting. The lack of statutory bylaws in the study areas coupled with an inefficient national regulatory framework could further undermine conservation efforts. Reference [59] have noted that despite sporadic efforts by government authorities in Sierra Leone to control unscrupulous exploitation of mangroves, mangroves are not legally protected, and the only regulations are through traditional restrictions or international treaties affecting countries along the coast. According to [65], inefficient national policies; legislation, and management strategies could in diverse ways affect the sustainability of mangroves. Reference [24] asserted that the mangrove ecosystem may be vulnerable to unsustainable exploitation where there are no stringent laws governing resource use.

Retrospectively, the philosophy by a large number of respondents (N=85%) with a dominant proportion from Kassiri and Kychom (n=55%) to retain the so-called "inherited" mangrove soil as "farmland" from their predecessors, spoke volume of the daunting will by the locals to allow restoration of mangrove in the farming-utilized and degraded mangrove soil. Similar assertions by coastal communities have been noted by [43], [52]. An almost rhetorical question posed to respondents in the farming communities in place of their absolute will to allow replanting of mangrove on the farmed soils, yielded the following arguable responses in the exact expressions "*Who pays our medical and school bills when we stop farming and salt production for conservation?; who feeds and shelter us?".* By implications, exploiting the resources to solve the current needs, regardless of any possible intergenerational costs, was a chance the locals were willing to explore. Studies have shown that mangrove conversions might bring profitable short-term benefits and far-reaching short- to long-term implications to its goods and services for human wellbeing [17], [53].

Prospects

Figure 2 shows that 86% of respondents were engaged in economic activities related to mangroves. Therefore, it is possible that sensitizing the locals well enough on the benefits of preserved mangroves, including the economic and regulatory benefits, could foster a positive attitude towards resource sustainability in the Scarcies Estuary. Also, the provision of financial capital as a loan to the people through 'Micro-Financing Systems', most especially the farming population, could enable farmers to explore alternative economic options including fishing and possibly limit the intensity of conversion of mangrove to rice fields, which is the herculean driver of mangrove loss in the Scarcies Estuaries. Reference [64] has emphasized the effectiveness of "Bio-rights" through the provision of funding to local communities who may have only limited access to credit mechanisms to improving the will of locals towards resource conservation. Other researchers have emphasized the need for support to alternative livelihood to succeed in mangrove conservation efforts [4], [63]. Reference [37] has shown that mangrove conservation efforts in the Scarcies River Estuary cannot be successful without due considerations of the varying impacts of poverty, gender roles, and resource utilization patterns. Moreover, there have been some success stories. According to [20], some efforts have been made to provide alternative livelihood by "beekeeping" as well as restoring mangroves in Mambolo through the GEF Small Grant Project (2018-2019). Reference [52] have revealed a concerted effort by USAID encouraging rice farmers in mangrove areas of Sierra Leone including the Scarcies Estuary to inculcate agro-silviculture in their rice farms in 2017; and though the idea was met with uneasiness by the locals, 55% incorporated the idea countrywide and these, as at 2018 were reaping the benefits of land protection against soil erosion.

Also, the Scarcity River Estuary is among those River Estuaries with delineated areas declared 'Marine Protected' in Sierra Leone, and there is in existence Community Management Associations (CMA`s) established by the Government of Sierra Leone through the Ministry of Fisheries and Marine Resources (MFMR), complemented by other concerned ministries, department, and agencies. Therefore, capacitating the CMAs to fully enforce their mandates which include policing mangrove areas of critical importance to fish spawning and nurseries could influence downscaling of the unscrupulous exploitation and degradation of the Scarcies Estuarine mangroves. Reference [39] concur that the establishment of protected areas is key for the protection and recovery of habitats and species. According to [34], the effectiveness of mangrove protection within protected areas is highly variable through poorly designed or inefficient enforcement and thus fails to prevent mangrove loss and degradation.

Further, the tribal authorities reported several failed attempts to get their local laws (bylaws) enacted by the legislative wing of the government of Sierra Leone between 2010 and 2013. However, such a positive stride was seemingly promising for co-management of the mangrove resources in the area. Reference [6] have suggested that the decision to allow local management efforts should be based on the capability of communities to effectively enforce their local rules and manage the forest sustainably. Other scholars have emphasized the relevance of traditional laws to control unscrupulous exploitation of

the natural capital [24], [62], [63]. Reference [59] has also noted frantic efforts by chiefdom authorities to regulate coastal resource exploitations through bylaws; though the efficiency of such an approach to management needs to be assessed [33].

Finally, despite widespread deforestation, the remaining mangrove trees in the Scarcies Estuaries are in good health, with high species diversity, mature forest, and high regeneration level [59], implying high production potential should human pressures be lowered or better managed.

IV. CONCLUSION

The study was conducted in five communities, and well-represented of the Great Scarcies River Estuary that constituted the bulk of the mangroves in the area. Rice fields, commercial salt production, and infrastructural development were the main aspects of mangrove conversions in the Scarcies Estuary. Rokupr and Mambolo recorded the highest of the conversion of mangroves to rice fields, while Kychom and Kassiri gravely converted the mangrove to salt pans. Clearing of mangroves for shelter was most dominantly practiced in Yeliboya Island. Commercial rice farming was the dominant economic activity in the Scarcies Estuary, followed by Fishing.

Inefficient national resource governance policies, nationwide scaling cost of living, limited job options, and low technical and financial capacity for individuals to explore other productive income options such as fishing may be compelling the incentives for conversion of mangroves, a disincentive for resource restoration and conservation in the study areas. Low western education and low skilled training by individuals to attract skilled jobs could be heightening the challenges relating to mangrove conservation.

V. RECOMMENDATIONS

Fervent sensitization on the economic and environmental benefits of intact mangrove ecosystems, coupled with training on livelihood diversification supported by financial loans to farmers in place of exploring other income activities could foster a positive attitude towards mangrove restoration and co-management in the Scarcies Estaury.

Support to other farming produce such as cassava, groundnut, palm oil, etc., that can thrive well on the vast available terrestrial land in the farming communities, coupled with oyster farming practices can be an added advantage.

Capacitating the existing Community Management Associations (CMAs) for the marine environment can help curb invasions by woodcutters in restricted mangrove areas.

The establishment of a sea-wall in Yeliboya is important to protect life and property as well as save mangrove destruction.

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